

and Greenman placed in section *Verbesinaria*, revealed no significant differences. Since *V. pterocaula* has priority, it is necessary that *V. stenophylla* be reduced to a synonym of that species.

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### OBSERVATIONS ON WITCHES'-BROOM FORMATION, AUTOPARASITISM, AND NEW HOSTS IN PHORADENDRON

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During the course of field studies on *Arceuthobium* in the southwestern United States and Mexico, we also had the opportunity to make a number of collections of the related genus, *Phoradendron*. This report is a compilation of our observations on *Phoradendron*, including witches'-broom formation, autoparasitism, and some new hosts.

This research was supported, in part, by a cooperative agreement between the Rocky Mountain Forest and Range Experiment Station and the University of Colorado where the junior author was located during the conduct of the study. Herbaria abbreviations used here but not occurring in *Index Herbariorum* include: FPF—Forest Pathology Herbarium, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, and INIF—Instituto Nacional de Investigaciones Forestales, Mexico, D.F.

#### WITCHES'-BROOMS

Witches'-broom formation is a common symptom of conifers infected by *Arceuthobium*, but has not been reported previously to be associated with parasitism by *Phoradendron*. The only other reported instance of witches'-brooms caused by a member of the Loranthaceae is in Chile where brooms are induced by *Phrygilanthus tetrandrus* Eichler on *Populus* (Reiche, 1907; Kuijt, 1964). This report is verified (fig. 1) from collections made in Santiago, Chile (*Wiens 3833 UT*). Brooms in *Populus* consisted of masses of vertical branches that rose 5 to 10 ft. No broom formation was observed on native hosts attacked by this mistletoe.



FIG. 1. Witches'-broom on *Populus* induced by *Phrygilanthus tetrandrus*, Santiago, Chile.

In an area two miles south of La Cuesta along Highway 45, Durango, Mexico, we found *P. tomentosum* (DC.) Engelm. ex Gray ssp. *tomentosum* on several ocotillo plants, *Fouquieria fasciculata* (Roem. & Schult.) Nash (Wiens 3294, COLO; Hawksworth 324, FPF). The mistletoe was common nearby on *Forestiera*, and within a few miles on *Prosopis* and *Celtis*. The mistletoe plants on ocotillo were small (2 to 3 inches high), pale yellow, and generally of low vigor compared with those on the other hosts. Symptoms of infection included markedly swollen branches and formation of witches'-brooms (fig. 2).

During a recent trip to southeastern Utah, R. S. Peterson (pers. comm.) noted several massive witches'-brooms in Utah juniper, *Juniperus osteosperma* (Torr.) Little. His examinations showed that they were not of the type caused by rust fungi but, surprisingly, were associated with *P. juniperinum* Engelm. (fig. 3). The foliage in the broomed part of the tree was denser and darker green than in the non-broomed parts of the tree. Plants of *P. juniperinum* were distributed systemically throughout the brooms (Peterson 65-80, FPF) in a manner somewhat similar to parasitism of pines by certain dwarf-mistletoes, *Arceuthobium*

(Hawksworth, 1961; Kuijt, 1960). Non-systemic infections of *P. juniperinum* occurred both within the broomed and non-broomed parts of the tree. This is in contrast to *Arceuthobium* where non-systemic infections rarely occur on systemic brooms. Whether *P. juniperinum* actually stimulated development of latent or adventitious buds was not determined. The broom portions where the parasite developed systemically, however, had a dense, intricately branched live twig system. The non-broomed parts, conversely, possessed a sparsely branched, open branch system. Peterson has also observed similar brooms associated with *P. juniperinum* on *J. oteosperma* and *J. scopulorum* Sarg. at Bryce Canyon, Utah.

#### INTRA- AND INTER-SPECIFIC PARASITISM

Autoparasitism, i.e., the occurrence of one mistletoe on a different individual of the same species, has been reported for *P. serotinum* (Raf.) Johnston in Florida (Curtiss, 1878) and also for several tropical American mistletoes (Kuijt, 1964; Wellman, 1964). We have observed autoparasitism in *P. californicum* Nutt. near Tucson, Arizona, on the Mount Lemmon highway (Hawksworth & Lightle 174, FPF). We have also noticed autoparasitism in *P. tomentosum* ssp. *tomentosum* on Highway 40 about 50 miles east of Torreón, Chihuahua, Mexico (Wiens 2616, RSA) and in *P. villosum* (Nutt.) Nutt. ssp. *villosum* on Highway 30 3 miles south of Running Springs in the San Bernardino Mountains, California (Hawksworth 737, FPF).

The occurrence of mistletoes on other species and genera of mistletoe is common in the tropics (Kuijt, 1964; Wellman, 1964), but not in more temperate regions. The only previous instance that we are aware of in the United States is Brown's (1918) report of *P. californicum* on *P. tomentosum* (DC.) Engelm. ex Gray ssp. *macrophyllum* (Engelm.) Wiens in Arizona. In an area 3 miles east of the Mimbres River on Highway 180 in Grant Co., New Mexico, *P. juniperinum* was collected on *Juniperus deppeana* Steud. A closer examination of the collection (Hawksworth & Lightle 124a, FPF) revealed that an individual of the *P. juniperinum* was, in turn, parasitized by *P. villosum* ssp. *coryae* (Trel.) Wiens. The latter plant was young and had shoots only about one inch high. Typical individuals of *P. villosum* ssp. *coryae* were common in the vicinity on various oaks.

#### NEW AND UNUSUAL HOST-PARASITE COMBINATIONS

*Phoradendron californicum* Nutt. This mistletoe is a characteristic plant of the deserts of the southwestern United States and northwestern Mexico. Its hosts are principally leguminous shrubs (Wiens, 1964).

Harris et al. (1930) reported that the possible explanation for the "exceedingly rare" occurrence of *P. californicum* on creosote bush, *Larrea divaricata* (DC.) Coville, was that this shrub has a much higher osmotic concentration than the usual hosts for this mistletoe. The only case of parasitism of this shrub by *P. californicum* that they found was





FIG. 2. Witches'-broom on *Fouquieria fasciculata* caused by *Phoradendron tomentosum* subsp. *tomentosum*. Note hypertrophy and change in tropic response of branches on the broom. La Cuesta, Durango, Mexico.

at Sacaton, Arizona, near a pumping station where the soil moisture was abnormally high.

Our observations, and the listing of *Larrea divaricata* as an "occasional" host by Munz (1959), indicate that parasitism of this shrub is not as rare as the earlier reports suggested. We have found this host-parasite combination north of Amboy, San Bernardino Co., California, (Wiens 967, RSA) and in several localities in Arizona: Pinal Co., 10 miles north of Oracle Junction (Hawksworth 706, FPF) and near Apache Junction (Gill in 1965, FPF); Gila Co., 24 miles northwest of Globe (Lightle & Lampi 65-12, FPF) and Mohave Co., Black Range (Hawksworth & Peterson 723, FPF).

Similarly, L. S. Gill (pers. comm.) informs us that *P. californicum* is common on creosote bush in an area 11 to 15 miles south of San Felipe on the road to Puertecitos, Baja California, Mexico. He noted that wherever legumes were heavily infected, the associated creosote bushes were similarly infected (Gill, 1965, FPF). Creosote bush was not infected where it grew in pure stands or in association with legumes that were not attacked by the mistletoe.

*Phoradendron bolleanum* (Seem.) Eichler ssp. *bolleanum*. This mistletoe of northern Mexico exhibits "double specificity" that is unusual among phanerogamic parasites. Its principal hosts include a gymnosperm (*Juniperus*) and an angiosperm (*Arbutus*). We know of no other in-

stance where a mistletoe is essentially restricted to two such diverse genera. The occurrence of a Mexican mistletoe on *Arbutus* has been known for decades. Trelease (1916) questioned whether the same mistletoe occurred on such unrelated genera; however, Fosberg (1941) and Wiens (1964) stated that they were morphologically the same taxon. Our more recent observations in the Sierra Madre Occidental of Chihuahua and Durango confirm this. Usually *Arbutus* and *Juniperus* are infested with about equal frequency, although an occasional individual of *Arctostaphylos* is also attacked. Its occurrence on *Arctostaphylos* is perhaps not unexpected because of the close relationship of this genus to *Arbutus*. Cross inoculation experiments might be desirable to preclude the possibility that the populations on *Arbutus* and *Juniperus* are not morphologically indistinguishable physiological races.

*Phoradendron bolleanum* ssp. *pauciflorum* (Torr.) Wiens. This mistletoe is a common parasite of *Abies concolor* (Gord. & Glend.) Lindl. in Baja California, California, and in the Santa Catalina Mountains in Arizona (Wiens, 1964). In the Sierra San Pedro Mártir of Baja California we found it rarely parasitizing *Cupressus arizonica* var. *montana* (Wiggins) Little (*Hawksworth & Scharpf* 763, DS, FPF, INIF, UT). The mistletoe was present in the vicinity on *Abies*.

*Phoradendron bolleanum* ssp. *densum* (Torr.) Wiens, a mistletoe found on *Cupressus* and *Juniperus* in Arizona and California, also occurs on the lower parts of the Sierra San Pedro Mártir on *Juniperus californica* Carr. However, our observations indicate that here *P. bolleanum* ssp. *densum* is not sympatric with *Cupressus*, which occurs about 2,000 to 3,000 feet higher.

*Phoradendron villosum* (Nutt.) Nutt. ssp. *villosum*. This taxon is the common oak-infesting mistletoe of the Pacific Coast States, ranging from northern Baja California to central Oregon west of the Cascades (Wiens, 1964). In addition to oaks, it sometimes parasitizes *Umbellularia*, *Aesculus*, *Arctostaphylos*, *Castanopsis*, *Fraxinus*, *Adenostoma*, (McMinn, 1951) and *Rhus* when these grow in association with infected oaks.

In Baja California, this parasite occurs on two host species apparently not previously recorded in the literature, although both genera are infected in California. Along the road east of Rancho San Jose, on the approach to the Sierra San Pedro Mártir, we collected this mistletoe on *Adenostoma sparsifolium* Torr. (*Hawksworth & Scharpf* 754, DS, FPF, INIF) and on *Rhus ovata* Wats. (*Hawksworth & Scharpf* 757, DS, FPF, INIF). This mistletoe also occurs on the latter host 72 miles south of Ensenada on Mexico Route 1 (*Lightle & Gill* 64-36, DS, FPF, INIF). Several infected shrubs of both species were observed, sometimes at considerable distances from the closest infected oaks.

*Phoradendron villosum* ssp. *coryae* (Trel.) Wiens. This is the common mistletoe on oak in the southwestern United States and adjacent northern Mexico (Wiens, 1964). Along Highway 666, 16 miles north



FIG. 3. Witches'-broom on *Juniperus osteosperma* associated with *Phoradendron juniperinum*. The left branch is a massive broom about 8 feet across. Twenty-six miles west of Blanding, San Juan Co., Utah. Photograph by R. S. Peterson, U. S. Forest Service.

of Clifton, Greenlee Co., Arizona, *P. villosum* ssp. *coryae* was found on several bushes of *Condalia globosa* Johnston var. *pubescens* Johnston (Hawksworth & Lightle 138, FPF). The parasite was common nearby on associated *Quercus turbinella* Greene.

*Phoradendron juniperinum* Engelm. ssp. *juniperinum*. This mistletoe is a common parasite of *Juniperus* from Oregon and Colorado south to northern Mexico (Wiens, 1964). Hedgcock (1915) noted that it had been "reported on *Cupressus arizonica*," although he had not seen collections of it on this host. We have examined the following specimens of *P. juniperinum* ssp. *juniperinum* on *Cupressus arizonica*: Cochise Co., Chiricahua National Monument (Gill FP 89611, FPF) and Chiricahua Mountains, Rucker Canyon (Hawksworth & Peterson 803 FPF). Mexico: Chihuahua, 38 miles southwest of Matachic on Ocampo Road (Wiens 3439, COLO and Hawksworth 482, FPF, INIF).

This mistletoe also occurs occasionally on *Cupressus bakeri* Jeps. in California: Plumas Co., 1.5 miles west of Wheeler Peak, east of Greenville (Quick 62-93, CAS); Shasta Co., 2 miles east of Burney Springs



(Peterson 65-458, FPF). In the latter locality, *P. juniperinum* was associated with *P. bolleanum* ssp. *densum*.

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#### NOTES AND NEWS

The Hafner Publishing Company, 31 East 10th Street, New York, New York 10003, has recently reprinted several books of interest to botanists. The photographic reproductions are of a very good quality and the cloth bindings are stout. Among the facsimile editions are: *Flora of Bermuda*, by N. L. BRITTON, \$12.00; *Flora of the Hawaiian Islands*, by WILLIAM HILLEBRAND, \$20.00; *Liberty Hyde Bailey*, by A. D. RODGERS, \$10.00; *Flora of the Prairies and Plains of Central North America*, by P. A. RYDBERG, \$12.00; *Life of Mendel*, by HUGO ILTIS, \$5.75; *Taxonomic Terminology of the Higher Plants*, by H. I. FEATHERLY, \$4.25; and *Plant Sociology, the Study of Plant Communities*, by J. BRAUN-BLANQUET, \$8.00.